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The capelin (Mallotus villosus) population spawning on the Southeast Shoal, 1976

by

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INTRODUCTION

Capelin spawning on the Southeast Shoal of the Grand Bank was first observed in 1950 (Pitt, 1958). With the advent of a commercial capelin fishery in the early 1970's, the capelin population became exploited as it moved through ICNAF Division 3L and 3O to the spawning grounds on the Southeast Shoal in ICNAF Division 3N. Nominal catches of capelin in 1972 in Division 3LNO were 22,005 tons (ICNAF Stat. Bull. 1972) and 165,880 tons in 1975 (ICNAF Stat. Bull. 1975). The USSR and Norway have the largest capelin fisheries in this area.

In 1976, Norwegian and Icelandic fishermen reported that capelin catches on the Southeast Shoal were lower than 1975 catches and that capelin were not as abundant. The Norwegian catches of capelin support these observations: 1975 catch 35,903 tons; 1976 catch 23,183 tons; quota 53,000 tons. Canadian surveillance officers reported that Soviet fishing captains commented that fishing in 3LNO in 1976 was not as good as in other years. In addition, the catch per tow, estimated by Canadian boarding officers, was also down in 1976 (D. Barrett, D. Aylward pers. comm.). Calculations of catch per tow in ICNAF Division 3O yielded averages of 10 tons per tow in 1976 whereas averages of 15-20 tons per tow were common in 1975 (D. Barrett pers. comm.).

The capelin fishery on the Southeast Shoal normally runs for the duration of capelin spawning, that is, from about June 15 to July 15. However, in 1976, the fishery ended rather abruptly in the first few days of July. The Canadian research vessel A.T. Cameron was in the area until June 30 and on that day few capelin concentrations were detected although some Soviet vessels were still fishing. The Norwegians reported that by July 4 capelin, whales and birds had disappeared from the area and after that only one catch (July 10) was taken. The Norglobal and Norwegian fishing vessels left the area on July 12 (G. Sangolt pers. comm.).

The capelin situation on the Southeast Shoal is in contrast to that in inshore Newfoundland. Qualitative observations suggested that capelin spawning inshore were abundant in 1976.

The low abundance of capelin on the Southeast Shoal in 1976 was also unexpected in view of Winters (1975) analysis. He suggested that because of the decline in the stocks of 3 of the major capelin predators, cod, seals and whales, there would be a surplus of capelin available for human harvest. Incidental catches of capelin by the A.T. Cameron during the last few years (Fig. 1) also suggested that capelin were abundant.

The purpose of this paper is to examine possible causes for the decline of the Southeast Shoal capelin stock in 1976.

Capelin stock discrimination and migration

To some extent, the importance of the decline of Southeast Shoal capelin depends on whether this stock is considered to be discrete from capelin spawning inshore. For instance, if capelin migrated either inshore or to the Southeast Shoal to spawn because of changes in environmental factors from year to year, the decline of the Southeast Shoal capelin stock might be explained by changes in hydrographic conditions in 1976. Therefore, it is necessary to examine the evidence in support of or against the existence of discrete spawning stocks of capelin.

Prokhorov (1968) reported that Barents Sea capelin change their spawning area depending on the temperature regime. In cold years, capelin spawn in the western parts of the spawning area and in warm years they spawn to the east. Prokhorov suggested that the temperature regime of the Barents Sea observed for the last three months of the previous calendar year determines which area the capelin approach. Olsen (1968) also noted that temperature was an important factor in determining the site of capelin spawning. He noted that the rich year-classes of 1956, 1957, 1962 and 1963 all resulted from late eastern spawning in low temperatures. In 1960 and 1961 the spawning stock was large, spawned early in warm water and produced poor year-classes.

There have been no detailed studies in the Newfoundland area relating relative annual abundance of capelin and capelin movements to hydrographic conditions. Bakaneu et al. (1976) reported that in samples of capelin from Labrador and the north Newfoundland bank, the 1973 year-class was strong. This year-class was also dominant in Carscadden's (1976) samples from ICNAF Divisions 2J and 3K in October and November 1975. Water temperatures in 1972 were unusually low and in 1973 water temperatures for many places in the Newfoundland region were lower than average although not as low as the 1972 temperatures (Templeman 1975). Water temperatures in 1974 and 1975 were generally lower than the long-term mean over the Newfoundland and Labrador areas (ICNAF Redbook 1975 and 1976). Winters (1974a) suggested that water temperatures influenced growth and maturation rate but their effect on survival to spawning and migration is not known.

The pattern of capelin migrations to the Southeast Shoal appears to be relatively constant each year. Schools of capelin first appear in ICNAF Division 3L in March or April and at this time the Soviet capelin fishery usually begins. Gradually these capelin move south through Division 3L and into 30 arriving on the spawning grounds in 3N in June. Evidence from cod tagging suggests that some of these capelin move inshore to spawn on Newfoundland beaches (Templeman and Fleming 1962). The capelin fishery is prosecuted from March through July in Division 3LNO on capelin that would spawn inshore and on the Southeast Shoal. This general movement through 3LO to 3N is a predictable annual occurrence and unlike the movement of the Barents Sea capelin hydrographic influences in the Newfoundland area would appear to be less important.

Inspection of the age-composition and age-at-length of mature capelin taken in June from the Southeast Shoal (Table 1) and inshore in 3P (Table 2) and 3L (Table 3) shows that there is little resemblance among the three areas. Capelin spawning on the Southeast Shoal have exhibited a great deal of variation in age composition from year to year. In 3L, with the exception of 1976, 4-year-olds have dominated the spawning population. In 3P, 3-year-olds have been most numerous for the years in which data are available. These differences between populations would suggest that capelin spawning in different areas are distinct stocks. Winters (1974b) demonstrated that growth of capelin differed in different areas.

Leggett et al. (1976) have presented morphometric and meristic evidence suggesting that capelin spawning on the Southeast Shoal are a discrete population. Although these data are preliminary, when taken with the knowledge that this migration is a predictable annual occurrence, it seems probable that the capelin spawning on the Southeast Shoal comprise a distinct stock. Hence for the purpose of this paper, this spawning population is assumed to be discrete.

Catch-effort statistics - 3LNO

The first offshore capelin catches from 3LNO reported to ICNAF were taken in 1972. Consequently, long-term catch and effort records are not available. However, we have calculated and tabulated detailed catch/effort statistics for 3LNO (Table 4). In 1972, 1973 and 1974 the Industrial Development Branch of Environment Canada chartered a number of midwater trawlers to assess the capelin potential in the Northwest Atlantic (Hinds 1975) and catch per unit effort (CPUE) data were calculated from information in this report. In 1974, personnel from the Newfoundland Biological Station were aboard the Norwegian vessel Meloyvaer fishing capelin on the Southeast Shoal and calculations of CPUE were made from two trips. For 1972 and 1973, the catches of capelin of the USSR were taken from Table 5, ICNAF Statistical Bulletins and it was assumed that all catches of the "other finfish" column were capelin. No adjustments were made in the effort statistics although undoubtedly some effort was expended for species other than capelin. As a result, it is possible that CPUE data calculated for these years for USSR are underestimates. However, the date for catches were not used unless the catch in the "other fihfish" category comprised a substantial portion of the total catch for that particular country, gear type and tonnage class of vessel. Boardings by Canadian surveillance officers resulted in catch/day calculations (R. Prier pers. comm.) and these are also given in Table 4. Other CPUE calculations for USSR vessels in 3LNO in 1976 are calculated from ICNAF Circular Letters - Provisional Catches and Effort. These are undoubtedly incorrect because of incomplete reportings; however, they are included for completeness.

The estimates of USSR CPUE based on ICNAF statistics are relatively constant from 1972 to 1975. It is known from boardings by Canadian fishery officers that most (about 95%) of the Russian capelin catch is frozen for human consumption (D. Barrett Pers. comm.). Soviet vessels are known to have a daily freezing capacity of between 30 to 50 tons but because capelin are small and freeze more quickly, the daily capacity is at least one-third higher, that is, 39.9 to 66.5 tons (R. Prier pers. comm.). Thus, estimated daily catches of Soviet vessels based on ICNAF statistics are well within the processing capacity of Soviet vessels and, in fact, it would appear that total freezing potential was not being reached. Based on catches made by smaller Canadian boats inexperienced in fishing capelin, USSR catches/day in 1972, 1973 and perhaps in 1974 could have been substantially higher and could have fulfilled the processing capability of the vessels. Estimates of catch/day made by Soviet vessels in 1975 based on the ICNAF Statistical Bulletin were higher than other years and Spanish estimates (Labarta 1976) were also high. Thus, catch/day by Soviet vessels was apparently low in 1976 compared to 1975 and perhaps lower than catch/day in 1972, 1973 and 1974.

The Canadian surveillance estimates of catch/day of the Soviet fleet in 3LNO in 1976 reveal an unexpected trend. Capelin in 3L in March and April are forming schools of mature and immature fish prior to spawning (Seliverstov and Kovalev 1976). At this time schools and catches would be expected to be smaller than in Division 3N when capelin have formed spawning schools. CPUE data from 1973 and 1975 support this idea. However, Canadian surveillance data suggest that the opposite occurred in 1976 indicating that capelin were not abundant on the Southeast Shoal that year.

Fishing intensity on the Southeast Shoal is heavy over a relatively small area; we have observed up to 60 fishing vessels actively fishing in an area of approximatley 400 square miles. Thus, when fish concentrations are heavy and there is a limit to the daily processing capacity of fishing vessels, the use of catch/day as CPUE data may not be useful if the processing capacity is reached within a fishing day. However, the fact that the Canadian surveillance catch/day estimates for Soviet vessels in 3NO were well below the processing capacity of these vessels adds further support to the observation that capelin were not abundant in ICNAF Division 3N in 1976.

Biological characteristics

Calculations of age-composition and length-at-age of mature capelin sampled during June on the Southeast Shoal revealed that age 3 (1973 year-class) was strong in males and dominated in females (Table 1). Although 3-year-old fish have dominated in the spawning population in June of other years (eg. 1967, 1970, 1975), the highest percentage of 3 year-old fish occurred in 1976. Mean lengths-at-age of all age-classes in 1976 were smaller than in previous years. In fact, fish of a year-class taken in 1976 were smaller than the same year-class taken in 1975. This would support Winters (1974) suggestion that slow-growing fish mature at an older age. Errors in age reading are not believed to account for this variation. These otoliths were read a minimum of 3 times by an experienced reader. The reader did note that these otoliths were more difficult to read than usual; this difficulty may have occurred because the annual zones were closer together as a result of poor growth.

Winters (1974a) and Templeman (1948) have observed that older and larger fish spawn first. Thus it was suspected that the capelin spawning season on the Southeast Shoal had occurred earlier in 1976 and the smaller sizes of fish taken in June 1976 were from the latter part of the spawning run. A comparison of mean length of capelin from June 1976 (Table 1) to mean lengths of capelin taken in July of previous years (Table 5) revealed that for males, the 1976 June mean lengths were smaller than the July long-term mean. For females, the 1976 mean lengths were smaller for ages 5 and 6 and slightly larger for ages 3 and 4. In addition, the Norwegians landed the first capelin to the Norglobal on the Southeast Shoal on June 15 (G. Sangolt, pers. comm.) and Canadian surveillance reports indicated that between June 4 and 9, most capelin fishing activity was in Division 30 with very little activity in 3N (D. Aylward, pers. comm.). This would indicate that the fishery and hence the capelin spawning season did not start earlier than usual in 1976. Thus, the smaller lengths-at-age of capelin on the Southeast Shoal in 1976 would appear to be a real phenomenon and not due to the unusual timing of the spawning season.

Collections of capelin from ICNAF Divisions 2J and 3K during October and November 1976 (Table 6) revealed that 3-year-old males and females were still small even after a full growing season. Four-year-old males were only slightly larger than 4-year-olds sampled earlier in the year on the Southeast Shoal whereas 4-year-old females were substantially larger. These results support the observation that fish of the 1973 year-class were smaller than fish of other year-classes.

Winters (1974a) suggested that growth-induced differences in maturation rate were more important in explaining year-class dominance than variation in survival rate. Further he found consistent positive correlations between temperature and growth for each age-group of each sex. This suggested that the length achieved by any age-group was at least partially controlled by the bottom temperature two years previous to the sampling year. A similar analysis was performed using mean lengths from Table 1 and deviations from long-term bottom temperature (80 m). Temperature data were from hydrographic station 36 (47° 00'N, 49° 07'W) and for the two years previous to the sampling year, mean deviations from the long-term (1953-1975) mean were calculated. It was found that correlations between temperature deviations and mean lengths were not significant for 3- and 4-year-old males and females. Data from 1974 and 1975 appeared to deviate most from the trend noted by Winters (1974a). Mean lengths of fish from these years were larger yet water temperatures during the two years previous to 1974 and 1975 respectively were colder than the long-term mean. When regressions were recalculated omitting 1974 and 1975 data, all correlations were significant ($p < 0.05$) and positive. We have no explanations for the 1974 and 1975 deviations from the trend.

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Winters (1974a) also found a positive correlation between mean lengths of 3-year-old fish and proportion mature at age 3 and a negative correlation between mean lengths of 4-year-old fish and proportion maturing at age 4. This analysis was repeated using data for 3- and 4-year-old males and females in Table 1. No significant correlations were found.

The presence of a strong 1973 year-class was also noted by Bakanev et al (1976) and was evident in Carscadden's (1976) data from ICNAF Divisions 2J and 3K from fall 1975. This year-class was also dominant in populations of capelin spawning inshore in ICNAF Divisions 3P and 3L (Table 2 and 3). In 3L populations, 4-year-old fish dominated in both males and females except in 1976 when 3-year-old fish were most prevalent. In 3P, 3-year-old fish were normally more common but in 1976, 3-year-olds were even more numerous than in any previous years. In both 3L and 3P, mean lengths-at-age have been fairly constant from year-to-year, including 1976. The drastic reduction in mean length-at-age is not apparent in capelin populations in 3L and 3P as it was in 3N in 1976.

Maturity ogives for Grand Bank capelin were given by Winters (1974a) using data collected to 1973. These ogives have been recalculated using data from 1966 to 1976. Because of the difficulty of obtaining large numbers of immature fish, per mille length compositions were calculated for each sex and used in the calculation of the maturity ogives (Fleming 1960) in Fig. 2. Capelin used in the analysis were from offshore 3L January to May and 3NO May to July. The curve for males is similar to that given by Winters (1974a) and in this study 50% of the males mature at 168 mm. The shape of the female curve is slightly different from Winters' (1974a) and here 50% of the females mature at 144 mm.

Our samples from the Southeast Shoal in 1976 contained mostly mature fish. However, when the immatures were included the mean lengths of male and female 3-year-olds were 171 mm and 155 mm respectively. The actual proportions of immatures for this age-group were 8% for males and 1% for females. Because this is a spawning population, it is believed that the sampling was biassed towards mature fish and the samples were not representative of the entire population. As a result, these mean lengths are probably larger than mean lengths of that age-group in the population. These mean lengths represent the length at which 65% of the 3-year-old males would be mature and 80% of the females would be mature. Since the mean lengths calculated mainly from mature fish are over-estimates, the percent maturity is considered to be a maximum estimate. To properly use the calculated maturity ogive, representative samples of both immature and mature fish are needed; this is difficult to obtain since capelin often occur in separate schools of mature or immature fish (Seliverstov and Kovalev, 1976).

Data from the Southeast Shoal population in past years are also almost entirely from mature fish. However, using the estimates of mean lengths of mature fish as indicators and realizing that subsequent estimates of percent mature are maximum estimates, it can be seen that in 1976 a lower proportion than normal of 3-year-olds were maturing. The proportions of mature males approached this low level in 1973 and proportions of mature females was also low in 1972 and 1973; however, 1976 is the lowest to date. From samples taken in the fall of 1975, Carscadden (1976) reported that in Division 3K, 33% of the males and 51% of the females of the 1973 year-class were mature while in Division 2J, 80% of the males and 74% of the females of the 1973 year-class were mature.

In the past, only small numbers of immature capelin have been taken with spawning fish on the Southeast Shoal (Table 7) and usually immatures were taken in the early part of the spawning season. Until 1976, the highest proportions of immatures were taken in June 1969 when 2% of the males and 4% of the females were immature. In 1976 a greater percentage of immature males occurred although relatively few immature females were recorded. The proportions of immature capelin varied from catch to catch; in the case of males, proportions of immatures varied from 0% to 76% while for females, the proportions of immatures varied from 0% to 15%. However, because males were not as numerous as females in the catch the proportions of immatures in the entire catch was relatively small.

The proportions of mature capelin at different maturity stages for June collections are given in Fig. 3. A large proportion of both males and females had not spawned during this time period. In fact, a large proportion of capelin were still in maturity stage 1 indicating that these fish would probably not spawn for at least one week. On June 29, 1976 four sets were made with the midwater trawl and from the 1225 fish samples for maturity 13% of the males were immature and 48% were maturing but had not spawned. Of the females, 1% were immature and 85% were maturing but had not spawned. Thus, up until June 29 our samples indicated that a large proportion of both sexes were ripening but had not spawned. On June 30, only small concentrations of capelin were detected.

The sex ratios of capelin in ICNAF Division 3N for June are given in Table 8. In many years, females were taken more often than males. This is especially apparent since 1972 when most samples were taken with midwater trawl. This agrees with Winters' (1974a) suggestion that sexes are segregated vertically on the Southeast Shoal with males on the bottom and females located pelagically.

Hydrographic conditions

Capelin spawning on beaches in Newfoundland and Labrador prefer water temperatures of 5.5° - 8.5°C although some spawning does occur at water temperatures up to 10°C (Jangaard 1974). Pitt (1958) reported bottom temperatures on the Southeast Shoal ranging from 2.8°C to 4.7°C during capelin spawning in 1950 and 1951. Templeman (1965) listed the following dates and bottom temperatures for catches of capelin from the Southeast Shoal in 1961: July 8, 2.9°C, 1400 kg capelin; July 9, 3.1°C, 1700 kg capelin; July 22, 2.2°C, 1500 kg capelin. These earlier observations of preferred capelin spawning temperatures have been confirmed by recent trips to the Southeast Shoal (Table 9). In 1976 the area south of the heaviest capelin concentrations was also surveyed and few concentrations of capelin were observed, locations and bottom temperatures from this survey were as follows: 44° 24' 45"N, 50° 00' 00"W, 5.4°C; 44° 30'N, 50° 00'W, 5.0°C; 44° 35'N, 50° 00'W, 4.1°C. Although these are the only temperature data available from 1976, it appears that bottom temperatures were progressively warmer to the southern part of the Southeast Shoal. This may have restricted the capelin to a relatively small area on the northern part of the Southeast Shoal, centred at approximately 45° 00'N, 50° 10'W. We observed heavy concentrations of spawning capelin and heavy fishing activity in the same area in 1975. Seliverstov and Kovalev (1976) confirmed this observation although they did report heavy concentrations of capelin to the south of this area as well. Thus, capelin spawning on the Southeast Shoal in 1976 occurred in an area relatively small compared to 1975 and almost certainly smaller compared to previous years as well. Warmer water over the southern part of the shoal may have been the prime cause of this.

Typical profiles of water temperatures on the Southeast Shoal are shown in Fig. 4. These profiles more closely resemble the profiles from 1975 then 1972 (Sangolt and Ulltang 1976) except bottom temperatures shown for 1976 which are slightly colder (see also Table 9). Purse seining in 1975 was more successful than in other years when trawl were more efficient and Sangolt and Ulltang (1976) attributed this difference to temperature differences. It is doubtful that that differences in schooling patterns influenced by water temperatures could account for the drop in the Norwegian catch in 1976.

DISCUSSION

This study has revealed a number of unusual points concerning the Southeast Shoal capelin population in 1976. Observations of fishermen indicated that abundance of capelin was low and this was substantiated by Norwegian catches and CPUE data. The spawning season ended earlier than usual although evidence indicated that the spawning had started on or about the usual dates. Near the end of the spawning, there were large proportions of mature but unspawned fish in the samples. There were unusually high proportions of immature capelin mixed with the mature capelin on the spawning grounds. The spawning area on the Southeast Shoal in 1976 was apparently restricted in area, perhaps because of unfacourable temperature conditions on other parts of the shoal. Mean lengths-at-age of mature capelin were smaller than previous years and smaller than the long-term mean.

The low abundance of capelin on the Southeast Shoal may have occurred as a result of low proportions of the 1973 year-class maturing. Samples from fall catches of the previous year and from inshore and offshore spawning populations indicated that this year-class was relatively strong. However, a low percentage of this year-class may have matured because of slow growth. Comparisons of mean lengths of spawning capelin with the maturity ogives and samples from the previous fall add support to such a conclusion. The presence of relatively low numbers of the 1972 year-class spawning on the Southeast Shoal in 1976 would tend to accentuate the dominance of the 1973 year-class. In 1975, the 1972 year-class was fairly strong and the mean-length was approximately equal to the long-term mean. Thus, most of the 1972 year-class may have matured in 1975, leaving few to mature in 1976. This, in combination with low proportions of the 1973 year-class maturing in 1976, would contribute to the low abundance of capelin on the Southeast Shoal during the 1976 spawning season. The unusual presence of immature capelin with the mature fish is further evidence that larger proportion than usual of the 3-year-olds did not mature.

The lower proportions of 4-year-olds on the Southeast Shoal may have resulted from this group of fish spawning elsewhere. Our samples of inshore spawning capelin from Division 3P does not support such a conclusion. Three-year-olds normally dominate this population and 1976 was no exception. Samples from Division 3L are more difficult to interpret. In general, the proportions of 4-year-olds were lower than usual although this may be misleading because of the strength of age-group 3. The mean lengths of capelin from Division 3L were relatively constant from year-to-year and until 1976 were comparable to mean lengths of mature capelin from Division 3N. However, in 1976, capelin spawning in 3L were larger. This would suggest that larger fish of the 1972 year-class were moving inshore while smaller fish of this year-class were spawning offshore. Such an occurrence seems improbable in view of the similarities of mean lengths from previous years.

There are probably a number of factors influencing growth rates and maturation of a year-class. Although Winters (1974a) found that temperature was influencing growth, the results from this study suggest that the influence of temperature may not be strong. Density-dependent effects may also be occurring. A strong year-class may put in a heavy demand on available food thus resulting in poor growth. Winters (1975) surplus production model suggested that because of the reduction in numbers of major capelin predators, there would be a surplus of approximately 1.25 x 10^6 metric tons of capelin. The quota is presently 0.5 x 10^6 metric tons indicating that there would still be an abundance of capelin. This surplus of capelin, coupled with a strong year-class, could have resulted in density-dependent effects such as poor growth and low proportions maturing. Ulltang (1975) suggested that for Barents Sea capelin, poor growth had resulted because a series of strong year-classes had been too abundant for the available food. He also noted that these strong year-classes had occurred after the Norwegian fishery had taken out a large proportion of the spawning stock each year.

The influence of density-dependent effects does not apply to inshore spawning capelin. In Division 3L, for instance, the 1973 year-class was strong and in fact, reversed a trend in which 4-year-olds dominated the spawning population. In this case, mean lengths of the 3-year-olds were approximately the same as mean lengths of that age class from previous years. Growth was apparently not affected by the presence of a strong year-class. In Division 3P where 3-year-olds normally dominate, the strength of this year-class was maintained, especially for females. Again growth apparently was not sharply reduced.

The effect of the capelin fishery on the population dynamics of the Southeast Shoal stock is unknown. Although the fishery has been intense for at least 3 years, sampling data at times other than spawning are not available to follow year-class growth rates and maturation rates. Thus, it is impossible to determine the effect of the fishery on year-class strength and consequently on growth rate as Ulltang (1975) suggested may have occurred for Barents Sea capelin.

This year represents the last year of quotas established for three years (1975-1977) and therefore an evaluation of the present quotas should be considered. Winters (1975) suggested that the total quota should be 250,000 metric tons. This suggestion was based on Gjøsaeter's (1972) observations that the lowest estimate of abundance of Barents Sea capelin had been 20% of the average. Thus, for Newfoundland capelin, 20% of the surplus of 1.25 x 10^6 tons would be 250,000 tons. The quota was set by ICNAF at 500,000 tons with 200,000 tons allocated to Division 3LNOP and 300,000 tons allocated to Divisions 23K.

Because of the low abundance of capelin on the Southeast Shoal in 1976, it may be desirable to reduce some quotas to protect the stock. There are a number of ways that this could be accomplished. Since detailed knowledge of stock mixing in 2J3K is not available it may be desirable to reduce the entire quota by a common factor. On the other hand, a reduction in the quota only in the southern area could also be considered. Again because the details of stock mixing in Division 3L are not known a reduction in the entire 3LNO area by a constant factor could be imposed rather than a reduction only in Division 3N.

Because of the incidence of immature fish in the catches on the Southeast Shoal in June 1976 and because midwater trawls apparently are selective for females, it may be necessary to offer special protection to these elements of the population in Division 3N. A reduction in the quota would reduce both the numbers of immatures and females taken. A closed fishing season either during part of the spawning season or on specific days would also allow some escapement. However, an increased effort during the open fishing periods might counter any advantage gained by imposing a closed season.

Ulltang (1974) discussed the problems of setting quotas on the capelin stock in the Newfoundland area. Low quotas result in a loss in yield and it would probably extend the time necessary to get a reasonable estimate of the biomass. Quotas that are too high would result in serious consequences both for the capelin stock and its predators especially if carried over a number of years. In addition, if the immatures were exploited, the consequences would be serious. Because immatures were occurring in our catches on the Southeast Shoal in 1976 and in catches in 1975 in Division 2J3K and because it is now considered desirable to rebuild predator stocks, especially cod, in the ICNAF area, a conservative quota on capelin possibly incorporating a reduction in the present quota would seem preferable.

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REFERENCES

Bakanev, V.S., A.S. Seliverstov and L.I. Serebrov. 1976. Preliminary instrument estimate of abundance and biomass of capelin off South Labrador and the North Newfoundland Band (Divisions 2J and 3K). Intern. Comm. Northw. Atlant. Fish. Res. Doc. 76/54. Ser. No.3840,16 p.

Carscadden, J.E. 1976. Biological characteristics of capelin (Mallotus villosus) from Div. 3K and 2J in November 1975. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 76/62. Ser. No. 3849,5 p.

Fleming, A.M. 1960. Age, growth and sexual maturity of cod (Gadus morhua L.) in the Newfoundland area 1947-1950. J. Fish. Res. Board Can. 17(6): 775-809.

Gjøsaeter, J. 1972. Recruitment of the Barents Sea capelin 1951-1961. ICES C.M. 1972/H:24.

Hinds, L. 1975. Exploratory fishing for capelin in the N.W. Atlantic.Tech. Rept. Series No. 87. Ind. Dev. Branch. 211 p.

Jangaard, P. 1974. The capelin (Mallotus villosus). Biology, distribution, exploitation, utilization, and composition. Bull. 186. Fish. Res. Board Can. 70 p.

Labarta, E. 1976. Observations on the capelin fishery of the Grand Banks, Newfoundland, June-July 1975. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 76/9. Ser. No. 3778,11 p.

Leggett, W., J. Sharp, K. Able and J. Carscadden. 1976. Meristic and morphometric evidence for separate stocks of capelin (Mallotus villosus) in Canadian waters. ICES C.M./H:42.

Olsen, S. 1968. Some results of the Norwegian capelin investigations 1960-1965. Rapp. et Proc-Verb. 158: 18-23.

Pitt, T.K. 1958. Distribution, spawning and racial studies of the capelin, Mallotus villosus (Müller), in the offshore Newfoundland area. J. Fish. Res. Board Can. 15(3): 275-293.

Prokhorov, V. 1968. Materials on the ecology of capelin in the Barents Sea. Rapp. et Proc-Verb. 158: 23-31.

Sangolt, G. and O. Ulltang. 1976. Norwegian capelin fishery and capelin investigations in Newfoundland and Labrador waters in 1975. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 76/23 Ser. No. 3803, 8 p.

Seliverstov, A.S. and S.M. Kovalev. 1976. Size of the capelin spawning stock on the Grand Newfoundland Bank. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 76/51. Ser. No. 3837, 14 p.

Templeman, W. 1948. The life history of the capelin (Mallotus villosus O.F. Müller) in Newfoundland waters. Bull. Nfld. Govt. Lab. (Res.) 17:151 p.

1965. Some instances of cod and haddock behaviour and concentrations in the Newfoundland and Labrador areas in relation to food. Intern. Comm. Northw. Atlant. Fish. Spec. Publ. 6:449-461.

1975. Comparison of temperatures in July-August hydrographic sections of the Eastern Newfoundland Area in 1972 and 1973 with those from 1951 to 1971. Spec. Publ. 10. Intern. Comm. Northw. Atlant. Fish. 17:31.

Templeman, W. and A.M. Fleming. 1962. Cod tagging in the Newfoundland area during 1947 and 1948. J. Fish. Res. Board Can. 19(3): 445-487.

Ulltang, O. 1974. On the management of a capelin fishery. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 74/90. Ser. No. 3326, 7 p.

1975. The present capelin situation in the Barents Sea. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 75/4. Ser. No. 3432, 1 p.

Winters, G.H. 1974a. Some biological aspects and population parameters of Grand Bank capelin. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 74/76. Ser. No. 3309, 23 p.

1974b. Back-calculation of the growth of capelin (Mallotus villosus) in the Newfoundland area. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 74/7. Ser. No. 3150, 16 p.

1975. Review of capelin ecology and estimation of surplus yield from predator dynamics. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 75/2. Ser. No. 3430, 25 p.

Table 1. Percent composition and mean length-at-age (in parentheses) of mature capelin from ICNAF Division 3N, June only.

	Age(yr) and Length (mm)						
Males	2	3	4	5	6	7	N
1967		66(184)	30(191)	4(198)			307
1969	6(164)	23(182)	68(193)	4(193)			811
1970	4(166)	52(184)	40(189)	4(198)			25
1972		36(178)	63(185)	1(190)			106
1973		5(175)	86(179)	9(182)			44
1974		29(187)	41(193)	29(194)	2(192)		350
1975	5(168)	51(181)	42(194)	2(197)			539
1976		59(174)	37(176)	4(180)	1(181)		295
Mean (excluding 1976)	4(165)	37(182)	52(192)	7(194)	(192)		
Females							
1967		49(166)	31(173)	18(179)	2(189)		323
1969	16(146)	47(159)	32(170)	5(184)	1(194)		1000
1970		52(165)	28(176)	20(182)			25
1972		43(158)	52(169)	5(183)	1(186)		244
1973	1(148)	10(158)	82(165)	7(173)			256
1974	1(146)	28(166)	27(176)	42(179)	3(185)		400
1975	7(148)	39(163)	30(177)	12(185)	11(189)		1126
1976		72(155)	23(162)	4(175)	1(182)		1119
Mean (excluding 1976)	7(146)	39(161)	36(172)	13(185)	5(189)		

Table 2. Percent composition and mean length-at-age (in parentheses) of mature capelin from ICNAF Division 3P, June.

	Age(yr) and Length (mm)						
Males	2	3	4	5	6	7	N
1973	1(170)	48(174)	42(182)	8(186)			577
1974	15(173)	55(185)	21(191)	8(195)			978
1975	3(162)	71(187)	24(192)	1(190)	1(194)		563
1976		73(184)	25(187)	2(192)			890
Females							
1973	3(144)	49(160)	34(170)	14(173)			95
1974	21(160)	50(171)	22(178)	7(179)	1(187)		219
1975	6(139)	54(170)	29(180)	8(184)	2(197)		187
1976		72(167)	22(177)	5(191)	2(191)		60

Table 3. Percent composition and mean length-at-age (in parentheses) of mature capelin from ICNAF Division 3L, June.

	Age (yr) and Length (mm)						
Males	2	3	4	5	6	7	N
1967		21(188)	63(198)	15(201)	1(206)		920
1969		20(192)	76(194)	4(185)			50
1970							
1972		5(179)	95(188)				100
1973		3(178)	79(185)	18(187)			767
1974		24(187)	47(193)	29(196)	<1(195)		904
1975		26(187)	69(198)	4(200)	<1(206)		1241
1976		51(185)	48(194)	1(196)			1189
Females							
1967		16(166)	19(176)	62(182)	3(186)		613
1969							
1970							
1972		18(157)	75(168)	7(176)			100
1973		7(171)	67(171)	19(176)	2(193)		81
1974		17(166)	29(177)	51(181)	4(184)		342
1975		15(164)	51(179)	23(186)	24(187)	7(189)	156
1976		45(164)	28(175)	20(182)	2	5(200)	60

Table 4. Detailed CPUE statistics from 3LNO capelin fishery.

ICNAF Division	Month and/ or year	Country and/ or vessel	GRT and Gear	Catch per day	Catch per hour	Source
3N	May 1972	Canada - Foam V	399-MWT	6.8	2.3	Hinds 1975
	June 1972	" "		79.4	32.2	
	July 1972	" "		86.6	38.4	
	Combined 1972	" "		72.5	32.6	
	June 1972	Canada - Lady Janice	434-MWT	232.5	39.0	
	July 1972	"		167.0	53.9	
	June 1972	Foam I and Lady Janice		110	34.8	
	July 1972	"		113.4	44.7	
	All vessels, all months, 1972			100.8	38.1	
3N	June 1972	USSR	>2000 OT stern	49.4	4.8	ICNAF Statistical Bulletin
3N	June 1973	Canada - Foam V	399-MWT	62.8	6.8	Hinds 1975
	July 1973			47.5	6.8	
	Combined 1973			54.1	6.8	
	June 1973	Canada - Lady Patricia	207-MWT	87.5	11.7	
	July 1973			55.3	9.5	
	Combined 1973			59.1	9.8	
	June 1973	Canada-Newfoundland Hawke	835-MWT	102.5	9.5	
	July 1973			43.2	5.7	
	Combined 1973			50.2	6.3	
	All vessels - June 1973			75.7	8.2	
	July 1973			48.9	7.2	
	All months			54.5	7.5	
3N	June 1973	USSR	>2000 OT stern	47.5	5.4	ICNAF Statistical Bulletin
3L	May 1973	USSR	>2000 OT stern	24.9	2.3	"
3N	June 1974	Canada - Elizabeth Anne	198-MWT	55.0	29.9	Hinds 1975
	June 1974	Norway - Meloyvaer	708-MWT	226.7	52.3	Biological Station Records
	July 1974	"		70.5	17.4	
	Combined 1974			122.5	29.6	
3NO	May, June 1974	USSR	>2000 MWT	34.9	3.4	ICNAF Statistical Bulletin
3L	March, April, May 1975	USSR	>2000 MWT	46.2	3.5	ICNAF Statistical Bulletin

.....Cont'd.

Table 4 Cont'd.

ICNAF Division	Month and/ or year	Country and/ or vessel	GRT and Gear	Catch per day	Catch per hour	Source
3N	May, June July 1975	USSR	>2000-MWT	47.4	4.9	ICNAF Statistical Bulletin
30	May, June, July 1975	USSR	>2000-MWT	53.2	4.5	
3NO	May, June, July 1975	USSR	>2000-MWT	51.7	4.6	
3NO	June, July 1975	Spain	1500-MWT	90.4	11.6	Labarta 1976
3N	June 1975	Norway	500-999.9-Purse seine	472.0		ICNAF Statistical Bulletin
3N	July 1975	Norway	"	475.1		
3L	1975	USSR		38.7		Canadian Surveillance
3L	1976	USSR		45.5		Canadian Surveillance
3NO	1976	USSR		35.5		" "
3LNO	May 1976	USSR	>2000-MWT	539.0		ICNAF Circular Letters - Provisional
3LNO	June 1976	USSR	>2000-MWT	1796.2		Catches and Efforts
3LNO	July 1976	USSR	>2000-MWT	75.5		

Table 5. Percent composition and mean length at age (in parentheses) of mature capelin from ICNAF Division 3N, July.

	Age(yr) and Length(mm)					
Males	2	3	4	5	6	N
1967	28(156)	49(178)	20(189)	2(197)		255
1968	1(158)	36(184)	61(194)	1(197)		332
1969	1(166)	26(188)	73(195)			100
1972		33(176)	64(179)	2(198)	2(201)	272
1973	1(163)	8(174)	83(182)	9(184)		1049
1974		36(185)	40(192)	23(194)	2(197)	342
1975		50(172)	25		25	4
Mean	4(157)	24(180)	64(185)	8(189)	<1(196)	
Females						
1967	20(142)	61(155)	11(173)	7(180)		70
1968	13(143)	71(154)	14(168)	1(180)		255
1972		50(152)	27(170)	13(189)	8(199)	114
1973	5(142)	24(152)	67(160)	4(157)		199
1974	7(151)	47(158)	28(169)	19(175)		58
1975		4(176)	41(182)	20(191)	35(190)	46
Mean	8(143)	49(154)	33(160)	7(180)	3(193)	

Table 6. Percent composition, mean length-at-age (in parentheses) and percent maturity of capelin from ICNAF Divisions 2J and 3K, October and November, 1976.

	Age (yr) and Length (mm)					
	1	2	3	4	5	N
Males	2(128)	51(152)	45(173)	2(182)		167
% Mature	33	100	100	100		
Females	1(127)	44(140)	47(158)	7(187)	1(202)	132
% Mature	0	98	100	100	100	

Table 7. Percent immature capelin, by sex, for June, ICNAF Division 3N.

	MALES			FEMALES		
	Number of Immatures	Total	% Immatures	Number of Immatures	Total	% Immatures
1967	3	310	1	2	325	1
1969	17	828	2	40	1040	4
1970	0	25	0	0	25	0
1972	0	106	0	0	244	0
1973	0	44	0	0	256	0
1974	0	350	0	0	400	0
1975	1	540	<1	2	1128	<1
1976	225	902	25	124	3595	<1

Table 8. Sex ratios of mature capelin by sex for June, ICNAF Division 3N.

	% Males	% Females
1967	49	51
1969	45	55
1970	50	50
1972	30	70
1973	15	85
1974	47	53
1975	32	68
1976	21	79

Table 9. Summary of dates, locations and means of bottom temperatures where capelin were taken on the Southeast Shoal.

Dates	Boundaries of area from which capelin catches taken	No. of temp. obs.	Mean Bottom temp (°C) (Range)	Remarks
July 8 - 18 1968	43° 34'N, 44° 46'N 49° 07'W, 50° 22'W	8	4.7 (0.2-6.3)	Capelin were dead and spawning had been completed.
June 19 - July 2, 1969	44° 56' 30"N, 42° 51'N 49° 25'W, 50° 20'W	18	3.3 (0.1-4.7)	Large bottom concentrations of capelin on southern and western parts of Southeast Shoal.
June 20 - July 2 1975	44° 57' 30"N, 44° 05' 30"N 49° 11'W, 50° 40'W	30	2.6 (0.4-5.5)	
June 15 - June 30 1976	45° 13' 30"N, 44° 55'N 50° 11' 45"W, 50° 24' 45"W	21	2.3 (1.5-2.9)	

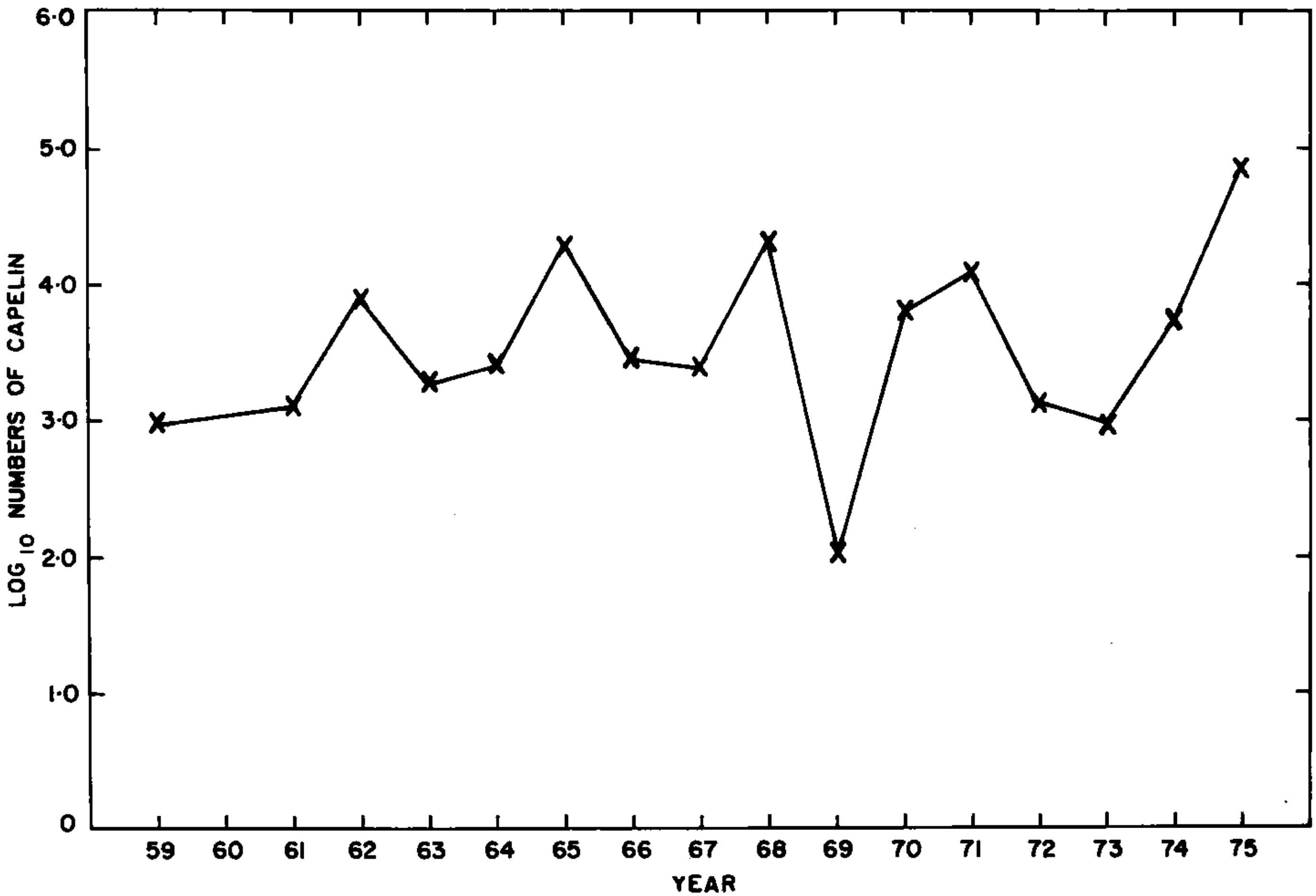

Fig. 1. Catches of capelin by otter trawl on <u>A.T. Cameron</u> during March-May, 1959-1975, ICNAF Division 3LO.

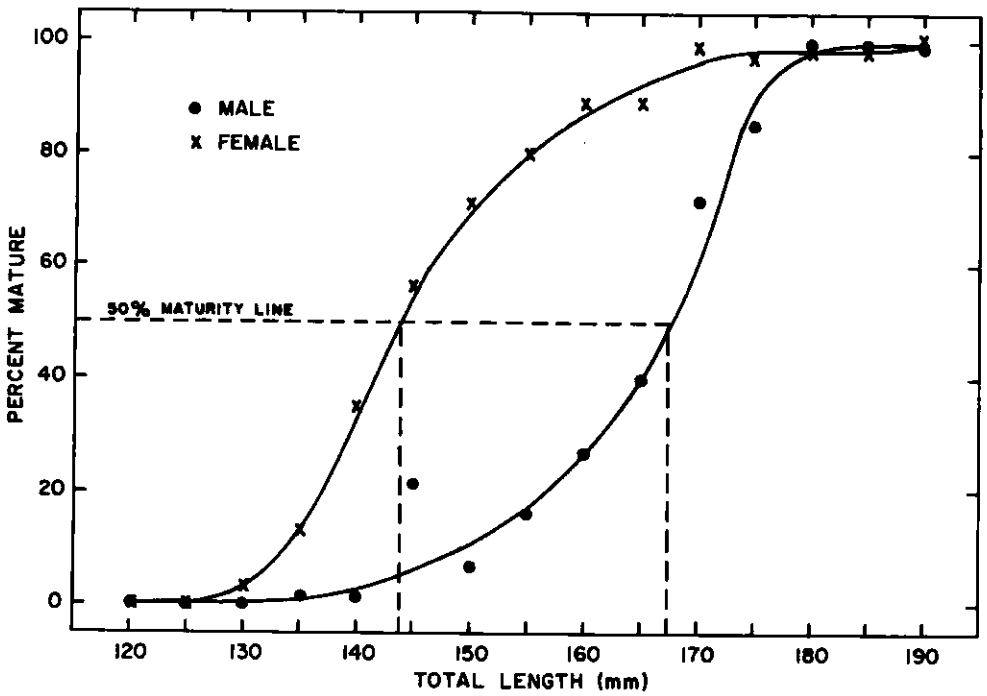

Fig. 2. Maturity ogives of male and female capelin from January-May, ICNAF Division 3L and May-July, ICNAF Division 3NO, 1966-1976.

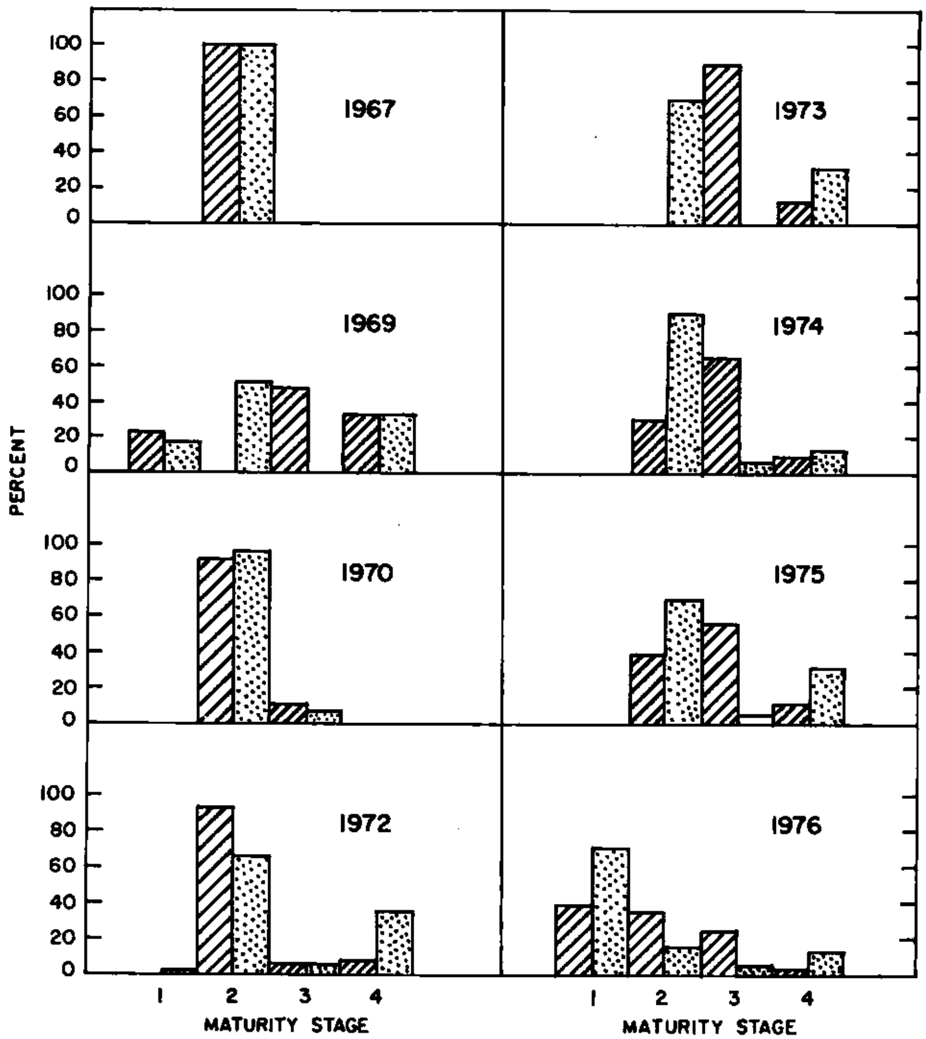

Fig. 3. Maturity composition of mature male and female capelin from Southeast Shoal, June. Males are cross-hatched and females are dots. Maturity 1 = maturing, maturity 2 = ripe, maturity 3 = spawning, maturity 4 = spent.

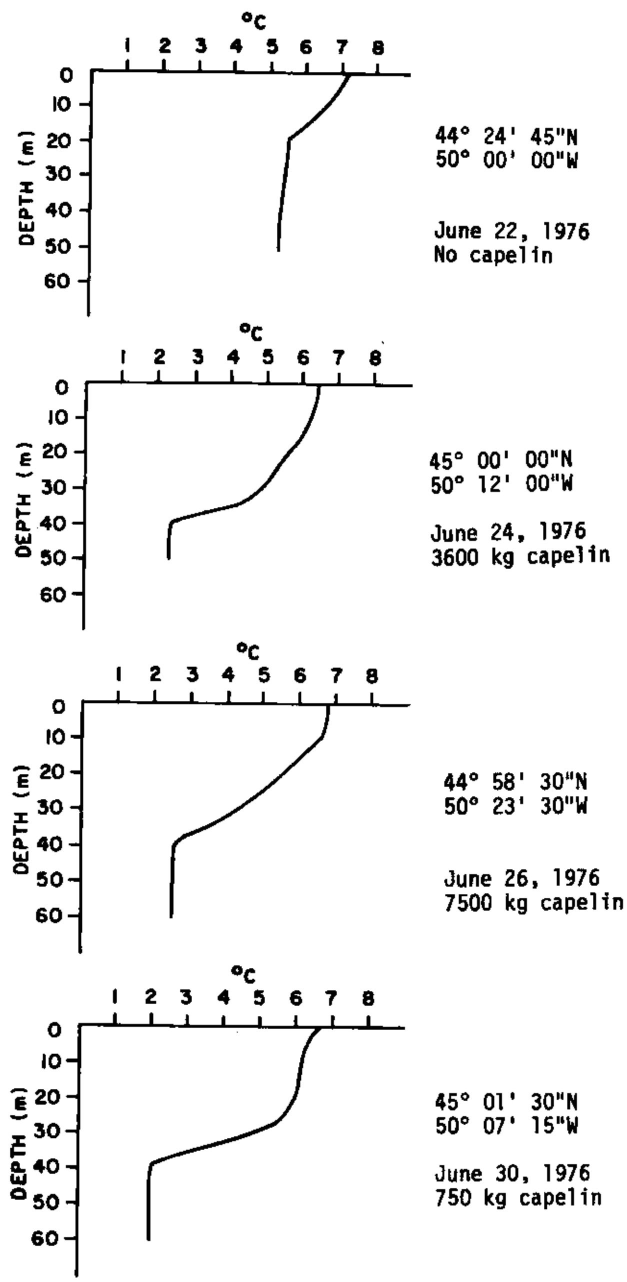

Fig. 4. Typical temperature profiles and atches of capelin from the Southeast Shoal, 1976.